Distribution and Abundance of Marbled Murrelets and Common Murres in Relation to Marine Habitat on the Outer Coast of Washington - An interim report to the *Tenyo Maru* Trustee Council

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Acknowledgments

First and foremost, I am extremely grateful to my crew: Bucky Barnett, Kirsten Brennan, and Monique Wilson - all extremely dedicated, skilled, responsible, resourceful, and personable. I also am indebted to the many other people in Washington Department of Fish and Wildlife (WDFW) for their help in various aspects of this study: D. John Pierce, Research Manager for WDFW, provided extensive logistical support and advice throughout this study; the enforcement division generously allowed us to use their enforcement vessel, the *"G.H. Corliss,"* stationed in Westport and captained by Dan O'Hagen who was tremendously cooperative and helpful; Steve Jeffries very generously allowed us use of his research vessel (*"Research 4"*), his vehicle for towing it, and all associated equipment (e.g., computers) necessary for recording observations in the field; his advice and cooperation were invaluable; Tom Owens, Tom Mumford, Dave Nysewander, Ken Warheit, Matt Vander Haegen and many others also provided valuable logistical support, advice and/or information. The Olympic Coast National Marine Sanctuary (Todd Jacobs and Ed Bowlby) kindly allowed us use of their research vessel, the *"Tatoosh,"* captained by George Galasso, to conduct seabird surveys. The U.S. Coast Guard stations at Neah Bay, LaPush, and Westport all were extremely cooperative and helpful by providing us with housing (Neah Bay), moorage and logistical support (weather data, mechanical help, fuel, etc.). Drs. John Wingfield and Dee Boersma of the University of Washington Department of Zoology (UW) generously provided me with office space and logistical support (computers, phone, Fax, e-mail, postage/mail, supplies). Dr. Julia Parrish (UW) has been a constant and reliable source of help and advice.

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Executive Summary

The mandate of the *Tenyo Maru* Trustee's Council is to restore resources damaged by the *Tenyo Maru* oil spill. Marbled Murrelets, *Brachyramphus marmoratus*, and Common Murres, *Uria aalge*, were documented by U. S. Fish and Wildlife Service and Washington Department of Fish and Wildlife to have been negatively impacted in the area of the outer coast of Washington affected by the *Tenyo Maru* oil spill. As a result, the Council funded us to accomplish two tasks with respect to these two species: (1) determine their at-sea distribution and abundance, and (2) determine their habitat preferences. To do so, it is necessary to be able to accurately count these species on the water. Unfortunately, methodologies for accurately counting these species at sea are poorly developed. Therefore, to accomplish the stated tasks, it is first necessary to validate a methodology for counting them at sea. In turn, in addition to obvious necessary logistical support (e.g., boats, personnel, etc.), one first must also (a) have appropriate computer software for collecting and analyzing field data, and (b) determine how their distribution and abundance is affected by biotic and abiotic environmental factors such as time of day, distance from shore, water depth, and prey abundance.

We have largely completed task one (development of computer software) and are well on the way to completing task two. Specifically, in collaboration with Ecological Consulting, Inc. (Portland, OR), we developed a very sophisticated set of computer programs specifically designed for collecting and analyzing at-sea distribution and abundance data with respect to biotic and abiotic environmental variables (geographic coordinates, habitat, water depth etc.). We currently are in the final stages of testing these programs and implementing minor modifications to them to improve their performance.

One goal of all censusing or sampling methodologies is to reduce sources of variability within treatments (e.g., species, locations, seasons, etc.) in order to maximize the probability of discriminating differences between or among treatment groups with a minimum of time, effort, and expense. Thus, for the purpose of designing a sampling methodology, the most important factors to understand are those that investigators have the most control over, and thereby can reduce within-treatment variability. Two such factors are time of day and distance from shore. Therefore, from 31 July through 27 September 1995, we conducted strip transects from boats (26 to 58 feet in length) at different times of day (early and late morning, early and late afternoon) and different distances from shore (200, 400, 800, and 1200 meters) along the outer Strait of Juan de Fuca and outer coast of Washington. Our results indicate that, independent of distance from shore, Marbled Murrelets are most abundant early in the morning and decrease throughout the day whereas Common Murres show no detectable change in abundance with time of day. Similarly, independent of time of day, Marbled Murrelets are most numerous close to shore (200 meters), and are rarely found at or beyond 1200 meters whereas Common Murre abundance is not correlated with distance from shore between 200 and 1200 meters. Since counts of murres are equally accurate at all times of day and distances from shore, our results suggest that accurate indices of both murres and murrelets can be obtained by conducting transects close to shore (200 or 400 meters) early in the morning. Our data also show that both species are much more abundant along the northern outer coast and outer Strait of Juan de Fuca than along the southern outer coast,

including Gray's Harbor and Willapa Bay. This pattern of abundance is correlated with the distribution of rocky vs. sandy coastline and benthic substrate, and with the proximity to nesting areas (old growth forest and Tatoosh Island for Marbled Murrelets and Common Murres, respectively).

Future plans are discussed to (1) improve methodology by investigating effects of other biotic and abiotic factors on Murre and Murrelet distribution and abundance, (2) use GIS kelp, shoreline/benthic substrate structure, and bathymetry (water depth) databases to determine the extent to which distribution and abundance of murres and murrelets are correlated with these factors, and (3) evaluate the potential value and limitations of aerial surveys.

INTRODUCTION

Washington Department of Fish and Wildlife (WDFW) was provided funds by the *Tenyo Maru* Trustee's Council to address two questions of concern: (1) what is the at-sea distribution and abundance of Common Murres, *Uria aalge*, and Marbled Murrelets, *Brachyramphus marmoratus*, on the "outer coast" of Washington (here defined as Port Angeles west to Neah Bay and Tatoosh Island, and south to the Columbia River), and (2) what at-sea habitats are preferred by Common Murres and Marbled Murrelets.

Objective 1: At-Sea Distribution and Abundance of Common Murres and Marbled Murrelets

Specific tasks identified in the original project proposal include:

(1) Identify sampling locations in impact area by reviewing relevant literature and interviewing biologists that have worked in the area.
(2) Develop Geographical Information System (GIS) software for the outer coast similar to the system developed for the Puget Sound Ambient Monitoring Program.
(3) Estimate abundance and distribution of murres and murrelets by both aerial and boat transects in summer and winter.
(4) On the NOAA ship *McArthur* collect seabird abundance and distribution data.

PROGRESS TO DATE

<u>Task 1</u>

We have corresponded extensively with biologists that have experience working on (1) Marbled Murrelets (hereafter murrelets) and/or Common Murres (hereafter murres), (2) Pacific seabirds in general (from California to Alaska, including British Columbia), and (3) biological issues regarding coastal Washington. This includes communications with most state and federal natural resource agency biologists, academia, Pacific Seabird Group, Colonial Waterbird Society, various Indian tribes (e.g., Makah), Northwest Indian Fisheries Commission, and private environmental consultants (e.g., Steve Speich, Terry Wahl, Tom Hamer). We have nearly completed an extensive search for relevant literature on murres, murrelets, Pacific seabirds in general, and other literature regarding aspects of data collection and analysis (for a list of bibliographic sources consulted to date, see Table 1). Most of this literature I either owned prior to joining WDFW or I have obtained in the last few months.

<u>Task 2</u>

We also have developed appropriate GIS computer software for collecting and analyzing abundance and distribution data. Dr. R. Glenn Ford of Ecological Consulting Inc., Portland, Oregon, was contracted by WDFW to develop this software. In fall of 1995, prior to development of this software, WDFW consulted with Glenn about capabilities that we wanted designed into the software. After he completed a preliminary version of the software, we tested it in the field in January and February 1996 at which time we identified some changes that we wanted made to the data collection part of the software. The modified software will be further evaluated in the field in February and March. If necessary, the software will be modified further until it meets our requirements. The data analysis portion of the program is very powerful (specific aspects discussed below). It allows one to generate maps in various formats of the density and distribution of species (e.g. Figures 13-14, 21-22). Data files can be imported directly into ARCINFO for Geographic Information System (GIS) analyses (also discussed below).

Task 3

A necessary prerequisite for determining the distribution and abundance of any bird, terrestrial or marine, is a valid methodology for counting them. This past summer, we began to develop a preliminary protocol for counting murres and murrelets (discussed further under section on "Differential Habitat Use" below). One of the most important issues is whether to count birds from boats, planes, or both. The answer to this question depends on the species of birds being counted, the questions for which the data are being collected, and whether it is necessary to apply "correction factors" to plane data in order to combine it with boat data. In general, for many reasons the use of planes to count murrelets may not be advisable except in rare circumstances. This is so because murrelets (1) are small and wary, often diving before they can be spotted from planes, (2) typically do not associate with other species and usually occur as single birds or pairs (figure 1), thereby making them more difficult to see than birds which tend to congregate in larger groups, and (3) are often difficult to distinguish from other similar species (e.g., Pigeon Guillemots) depending on the season.

I have analyzed bird count data collected simultaneously from boats and planes for the Puget Sound Ambient Monitoring Program (provided by David Nysewander, Janet Stein and Matthew Nixon). These empirical data clearly demonstrate that boat and air data can not simply be combined for most, if any, species, including murres and murrelets. For example, data on murrelets indicates that the ratio of birds counted on boats vs. planes ranges from 24:1 to 0.5:1 (figure 2), and that the variation in this ratio differs with the length of the transect (figure 3). This variation may be far too high to allow one to combine boat and air data in a meaningful fashion, and indicates an urgent need for additional research to address this issue.

Task 4

WDFW personnel other than myself and my crew conducted surveys of seabird distribution and abundance on the NOAA ship *McArthur* in the summer of 1994 and had already scheduled to do so again in July of 1995 prior to the beginning of our research program on the outer coast. Therefore, we did not conduct surveys on the McArthur in 1995 because we thought to do so would simply duplicate already existing WDFW efforts and would be an unwise use of Tenyo Maru funds.

Implications for Restoration

Repeatable and statistically valid sampling methods are essential in the analysis of at-sea distribution of seabirds. If *Tenyo Maru* restoration activities are to include an at-sea component, in terms of either monitoring changes in abundance, distribution, or habitat use, or relating seabird recovery to fish abundance and distribution, valid methods for counting and monitoring seabirds along the outer coast of Washington need to be tested and established. We have begun to develop methods specifically designed for counting murres and murrelets (discussed further under Objective 2 below). We anticipate that our future research will allow us to improve and refine our preliminary methods into an acceptable protocol suitable for long-term at-sea censusing of murres and murrelets in Washington state and analyses of those distribution and abundance data. We suggest that all future at-sea seabird work associated with the *Tenyo Maru* restoration should follow these protocols, regardless of whether the work is being conducted by a trustee agency or by other public or private organizations.

Data collected from planes should not be combined with data collected from boats unless a substantially more accurate correction method than currently exists can be empirically derived. Further, planes are not well suited for collecting at-sea data to address most questions regarding at-sea abundance and distribution. However, use of planes may be preferable for addressing large scale questions/problems, and in situations where it is logistically prohibitive to use boats.

Future Plans

We will conduct aerial surveys in winter to get instantaneous overviews of the distribution of murres and murrelets in February and March. Regardless of whether we can quantitatively combine these data with our boat data, these data are a valuable complement to our boat data and allow us to address many questions that can not addressed from a single boat.

We also will study the seabird data collected on the *McArthur* in July 1995, and incorporate it if possible into our database and analyses.

Although the analyses presented in this report are adequate in many respects, and are statistically valid, more refined and statistically powerful analyses are possible. We will complete these analyses this winter. In response to a presentation given at the 1995 annual meeting of Pacific Seabird Group in Victoria, B.C., WDFW was solicited by two peer-reviewed journals, *Colonial Waterbirds* and *Pacific Seabirds*, to submit papers to each for review and possible publication. Thus, we plan to do so.

Last, we will prepare a schedule indicating dates by which final products will be completed.

OBJECTIVE 2: Differential Use of Marine Habitats by Common Murres and Marbled Murrelets

Specific tasks funded:

(1) Survey effort will be designed to determine how abundance, distribution and behavior are correlated with habitat (shoreline type, submergent/surface vegetation) and other biotic and abiotic variables such as bathymetry (water depth), distance from shore, time of day, water salinity, temperature, weather conditions, tide, and prey abundance.

(2) Boat transects and land-based surveys will quantify use of (and behavior in) different habitats by murres and murrelets along the outer coast.

(3) Remote sensing will be examined to evaluate its effectiveness in identifying important scabird habitats.

PROGRESS TO DATE

Tasks 1 and 2

Understanding how to collect and analyze seabird abundance and distribution data is only the first step in successfully monitoring the at-sea component of a seabird restoration plan. Determining how murres and murrelets use the Washington outer coast ocean habitat (and how to define that habitat), and whether any component of this habitat can be manipulated as part of a restoration plan was the primary objective of this part of our pilot project. We defined "habitat" as any environmental variable that can influence murre or murrelet distribution, and includes bathymetry, distance from shore, water salinity and temperature, weather conditions, type and amount of surface and/or submergent vegetation, etc. *How* these seabird species use these habitats is just as important as *whether* they use these habitats.

Based on a review of the literature on seabird censusing methodology, murres, and murrelets, I identified time of day, distance from shore, water depth and tide as the most important and tractable factors that may influence the distribution and abundance of murres and murrelets. From 31 July through 27 September 1995, we conducted 60 surveys (figures 4-6) of the nearshore coastal waters of Washington. The location and timing of these surveys were designed to measure the influence of these variables on the distribution and abundance of murres and murrelets.

The results indicate that the density of murrelets decreases with both time of day (figures 7-9) and distance from shore (figures 10-11). Because depth is correlated, of course, with distance from shore, it is not surprising that murrelets are found most frequently at a water depth of about 40 feet (figure 12). The effect of distance from shore also is reflected in the density distribution maps below (figures 13-14). Conversely, however, neither time of day (figures 15-17) nor distance from shore (figures 18-20) had any significant effect on distribution and abundance of murres. This also is reflected in the density distribution maps below (figures 21-22).

Task 3

Our data also indicate that murrelets are more numerous along the northern outer coast and strait of Juan de Fuca than along the southern outer coast (figures 13-14). The reason for this is unknown. However, this pattern of abundance appears to be correlated with (1) proximity of old growth forest, (2) the distribution of rocky shoreline/substrate vs. sandy shoreline/substrate, and (3) abundance of kelp (based on data in the kelp GIS database provided to me by Tom Mumford, Washington Department of Natural Resources). More sophisticated and detailed analyses of these relationships are currently underway in collaboration with Tom Owens (WDFW, GIS specialist). The pattern of distribution and abundance of murres is more complicated. This is likely due, at least partly, to northward immigration in summer and fall of murres from Oregon (and possibly elsewhere). Murres fledge from breeding colonies in Oregon in late June or early July, on average, and disperse as far north as Cape Flattery by late July. In contrast, Washington murre colonies do not fledge until early August or later.

Implications For restoration

Restoration of murres and murrelets requires an understanding of (1) resources that are important to these species, and (2) the biological and physical environments in which these resources are found. The potential influence of these resources and their physical and biological environments, on seabird abundance and distribution must be understood before a valid sampling methodology can be designed. If this is not done, the effects of these factors on bird distribution and abundance will likely cause bird counts to vary much more than they would in a sampling methodology that controlled for these factors. This has two serious negative impacts: (1) Differences among counts may reflect differences among counts in the factors mentioned above and not true differences in numbers of birds, and (2) the large variation in the data reduces the probability of statistically detecting differences in bird counts among treatment groups (e.g., seasons, years, locations, habitats).

Our results indicate that murrelets are most numerous early in the morning and close to shore whereas murre densities do not change in relation to time of day or distance from shore. However, because counts of murres are equally accurate (i.e., unbiased) at all times of day and distances from shore, our results suggest that accurate indices of both murres and murrelets can be obtained by conducting transects close to shore (200 or 400 meters) early in the morning.

In addition, both murrelets and murres occur at higher densities along the northern outer coast and the Strait of Juan de Fuca than along the southern outer coast. In addition, neither species occurs in substantial numbers in Gray's Harbor or Willapa Bay - at least at the time we sampled (September).

The analyses described above document the relative importance of some physical and biological variables to these species. This provides us an preliminary guide for prioritizing our restoration efforts for managing these resources accordingly.

Future Plans

Using the software developed by Glenn Ford as well as WDFW GIS capabilities, we will overlay our abundance and distribution data for murres and murrelets on GIS databases of the distribution and abundance of (1) old growth forest, (2) shoreline/substrate structure, (3) kelp, and bathymetry (water depth) data (available from NOAA). These analyses will quantitatively indicate the strength of the correlation between abundance and distribution of murres and murrelets and these physical/biotic parameters. We also will design our winter sampling methodology to allow us to determine the extent to which these species, especially murrelets, occur in or near kelp (*Macrocystis* and/or *Nereocystis*).

Weather permitting, during our winter field season (January through March), we will repeat the transects we conducted along the outer Strait of Juan de Fuca to see if time of day and distance from shore have similar effects on the density of murrelets and murres that we observed during the summer. We also will survey as best we can the entire outer coast, including Gray's Harbor and Willapa Bay, to determine whether the winter distribution and abundance of these species differs significantly from the patterns we observed in summer and fall. In addition, it has been suggested that juvenile murrelets prefer to stay in or near kelp. Thus, we will address this through analyses of our data collected during (1) general sampling, (2) sampling designed specifically to look at possible habitat preference by adults or juveniles for kelp, and (3) adult/juvenile ratio sampling.

Table 1. Bibliographic sources consulted to identify literature regarding seabirds (especially Common Murres and Marbled Murrelets) in Washington state and measurement of their distribution and abundance.

1. Biological Abstracts (1971 to present).
2. Zoological Record (1978 to present).
3. Wildlife Review (1971 to present).
4. Water Resources Abstracts (1967 to present).
5. Aquatic Sciences and Fisheries Abstracts (1978 to present).
6. Life Sciences Abstracts (1986 to present).
7. National Technical Information Service (1978 to present).
8. Dissertation Abstracts.
9. Duckdata (10,000+ references on ducks compiled by Don Delnicky, USFWS).
10. Strong, R. (1939-1959) A bibliography of birds. Vols. 1-4. Field Museum of Natural History, Chicago, IL.
11. Coues, E. 1879. American ornithological bibliography, Third Installment (taxonomically indexed).
8. *Auk, American Ornithologists' Union Monographs, Wilson Bulletin, Condor*, and *Bird-Banding / Journal of Field Ornithology* (1955 to present).
9. *Ibis* (1955 to present).
10. *Cormorant / Marine Ornithology* (Journal of the South African Ornithological Society: Vol. 1 1976 to present).
11. *Notornis* (Journal of the New Zealand Ornithological Society, 1955 to present).
12. Recent Ornithological Literature (supplements to the *Auk, Ibis* and *Emu*: 1976 to present), and annual lists of recent seabird literature published in *Cormorant / Marine Ornithology*.
13. *Journal of Wildlife Management* (1937 - present), *Wildlife Monographs* (1958 - present) and *Wildlife Society Bulletin* (1973 - present).
14. Transactions of the North American Wildlife and Natural Resources Conference (from vol. 1, 1936 to present) .
15. *Canadian Journal of Zoology*, *Ecology*, *Ecological Monographs*, and *Ecological Applications* (1945 - present), and *Conservation Biology* (from vol. 1, 1986 - present).
16. Most major books and government documents (published and unpublished) regarding seabird biology.

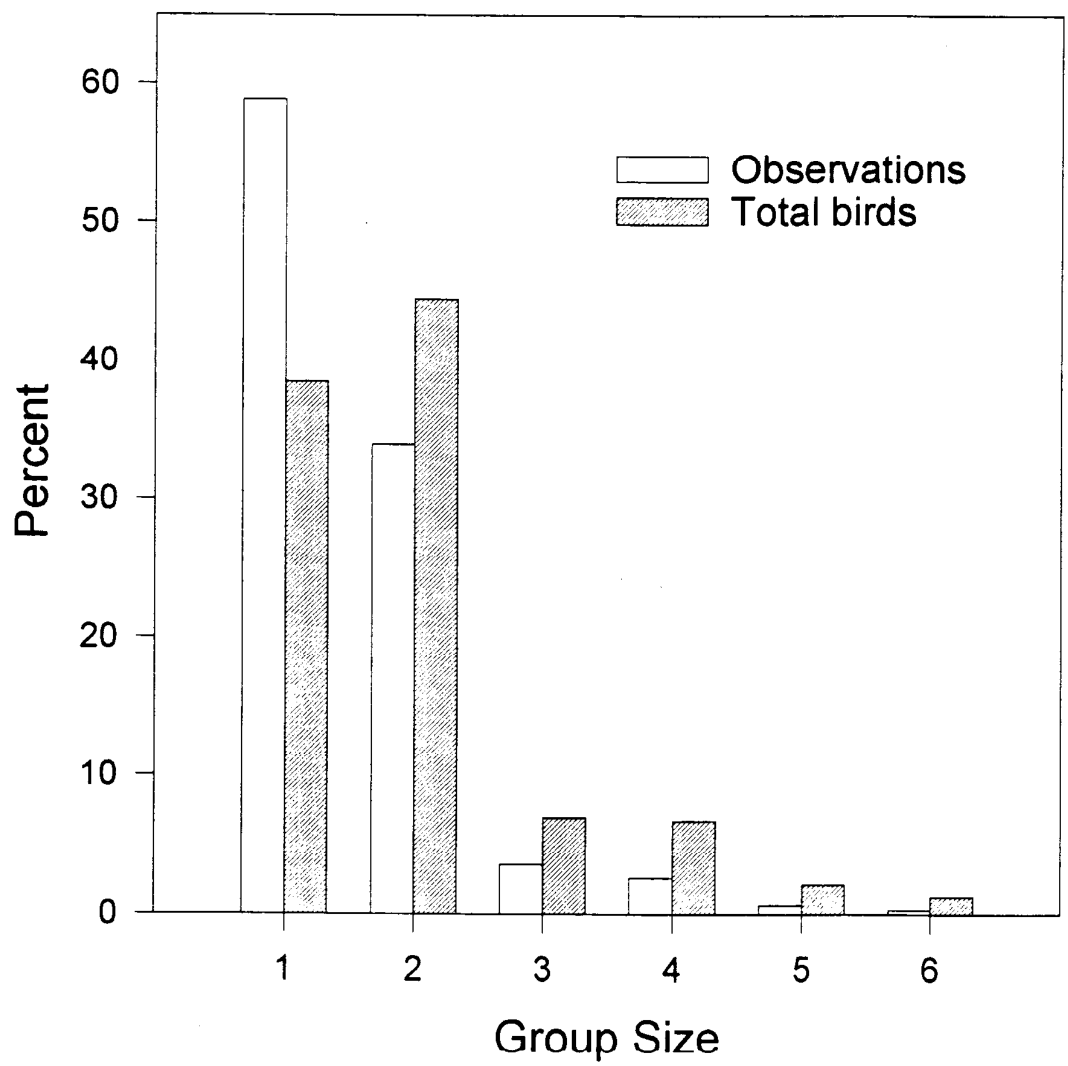

Figure 1. Frequency of Marbled Murrelets in relation to their group size

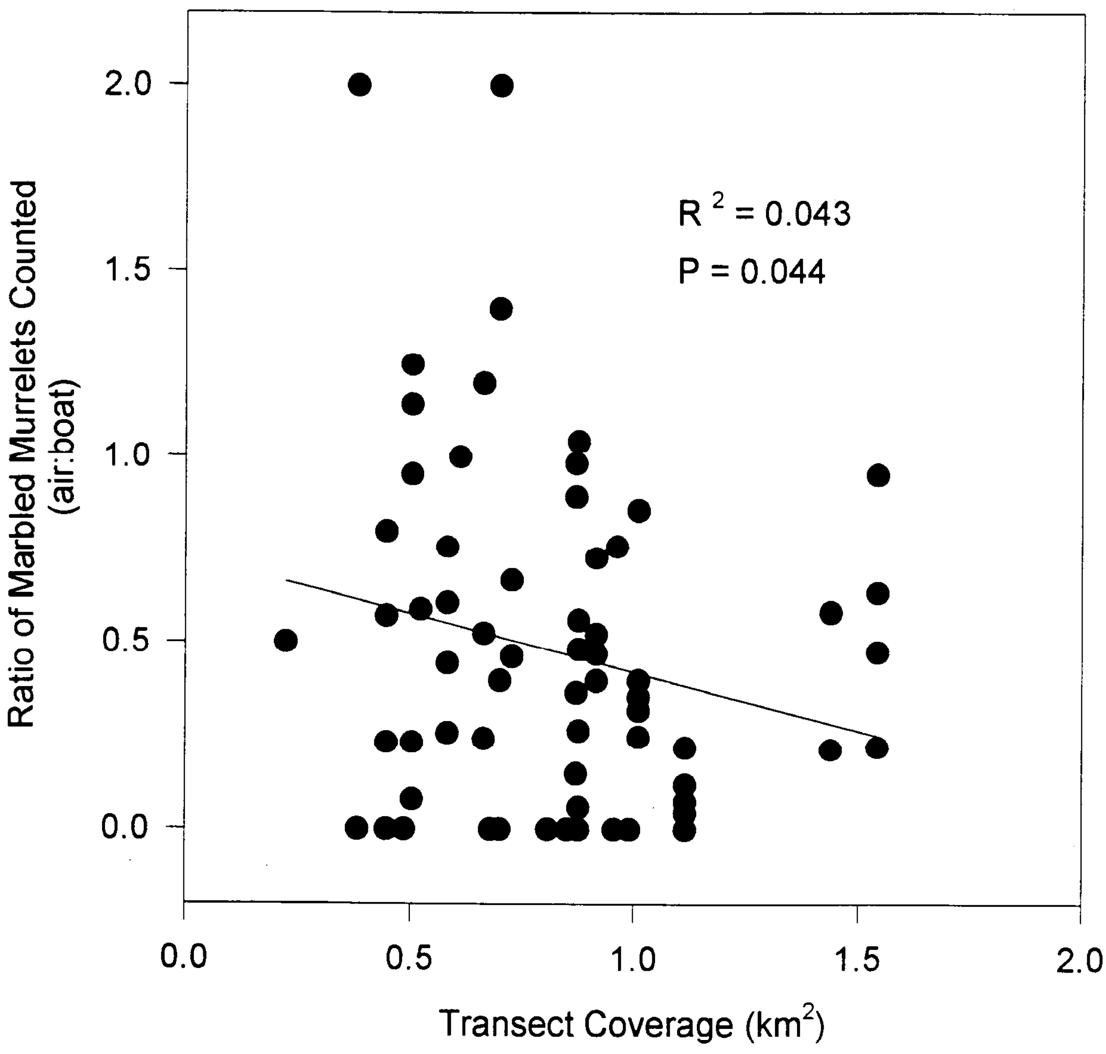

Figure 2. Ratio of Marbled Murrelets counted on simultaneous air and boat transects.

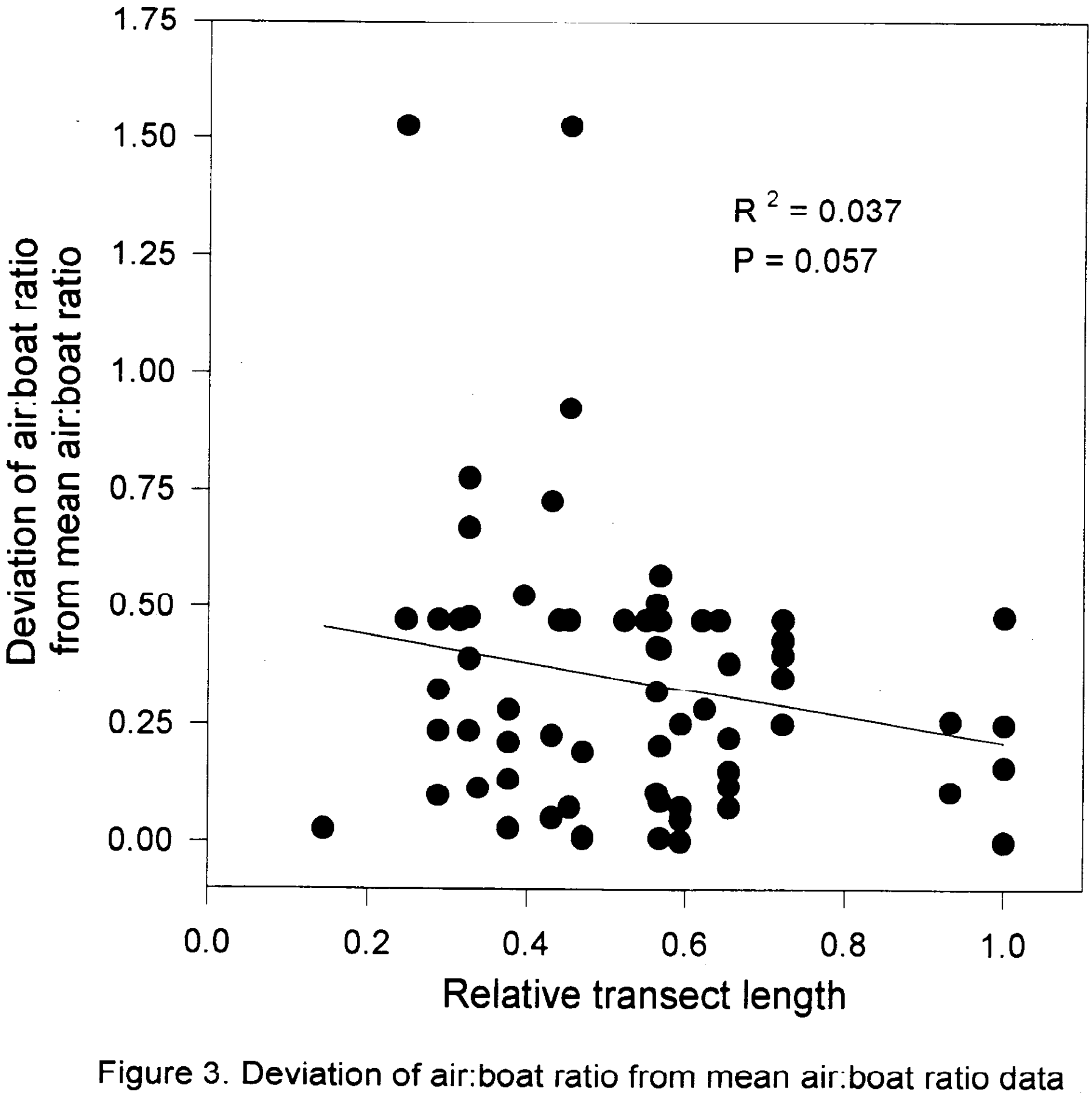

Figure 3. Deviation of air:boat ratio from mean air:boat ratio data presented in figure 2.

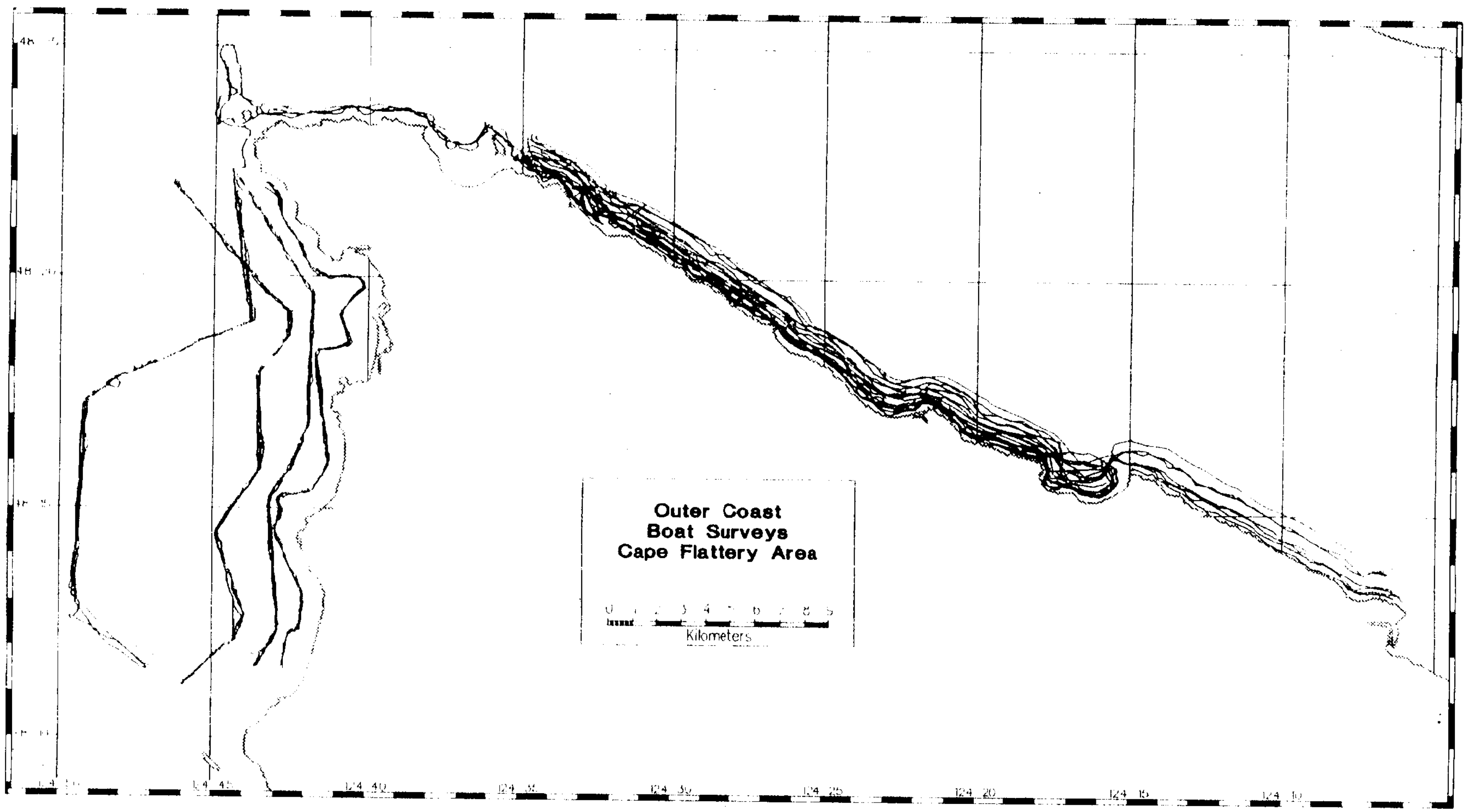

Figure 4. Transects conducted along the outer Strait of Juan de Fuca and northern outer coast from Cape Flattery south to Cape Alava.

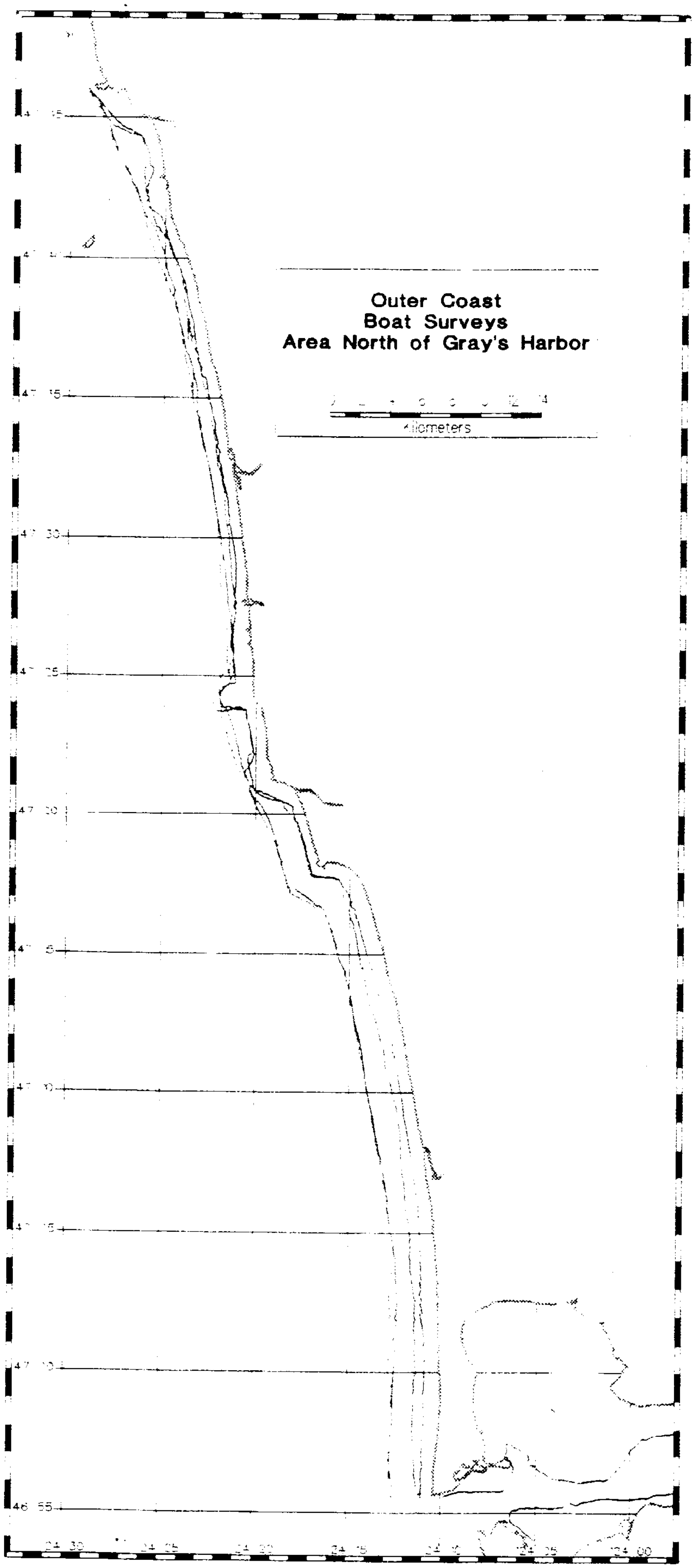

Figure 5. Transects conducted along the southern outer coast from Hoh Head south to Gray's Harbor.

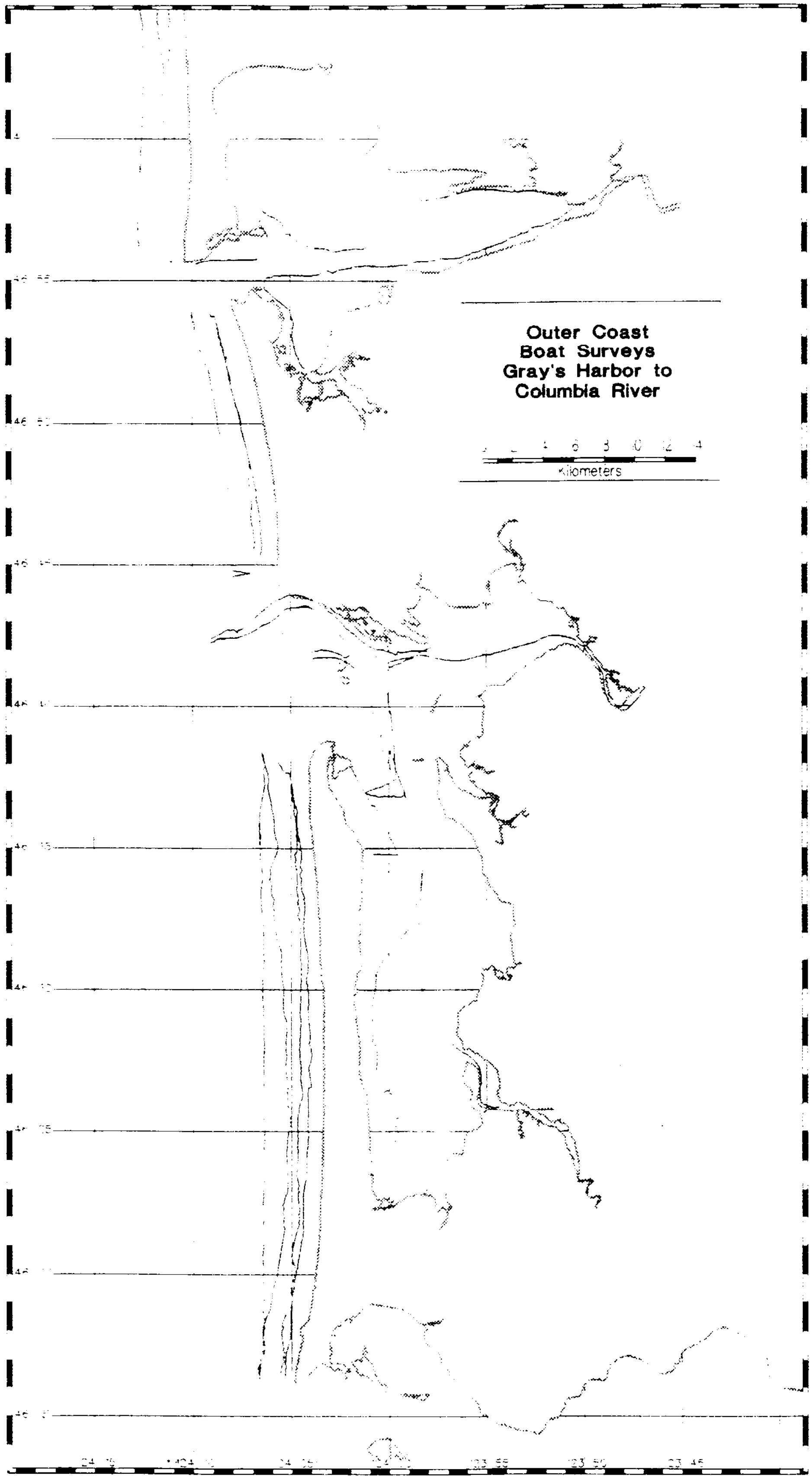

Figure 6. Transects conducted along the southern outer coast from Gray's Harbor south to the Columbia River.

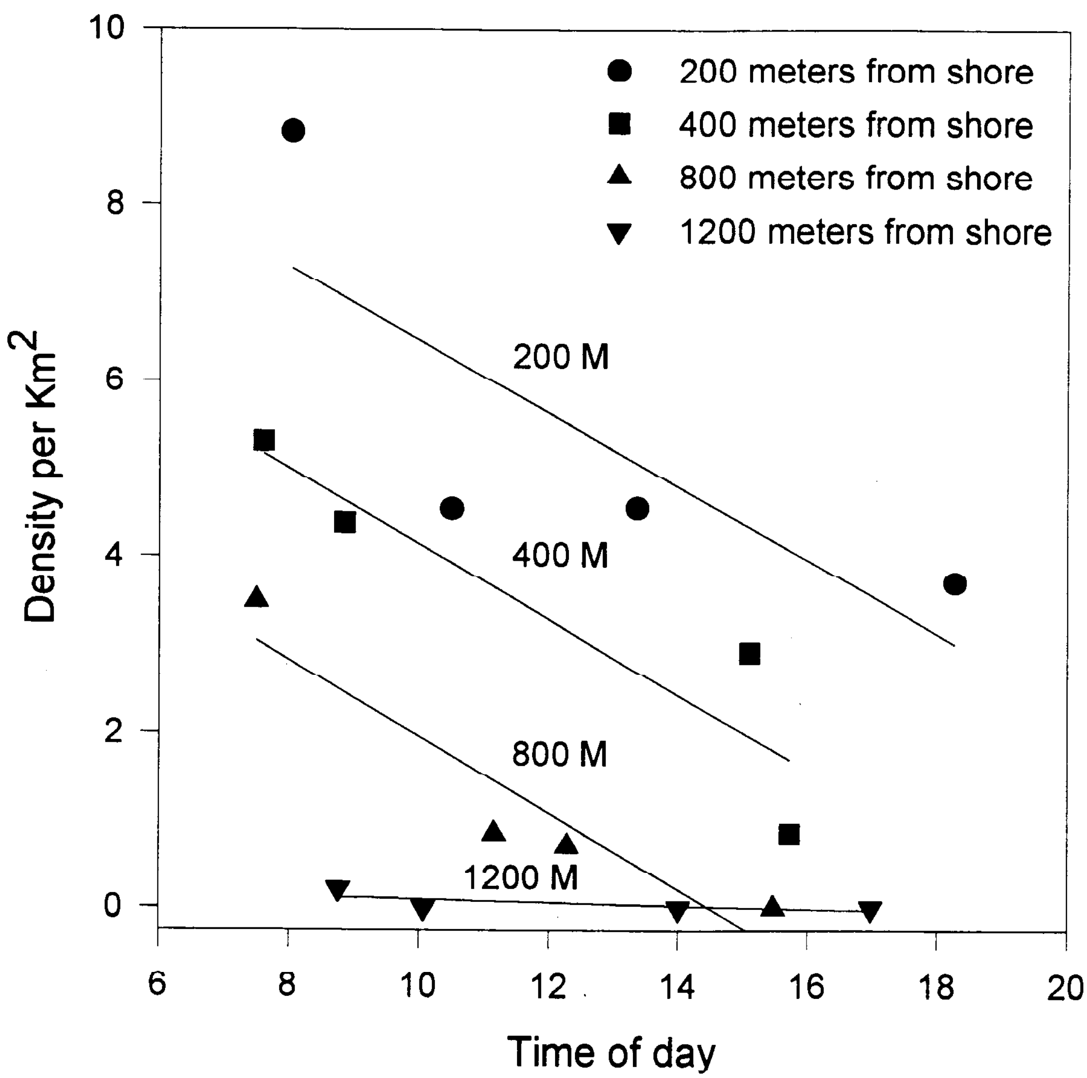

Figure 7. Summer density of Marbled Murrelets in relation to time of day along the outer Strait of Juan de Fuca

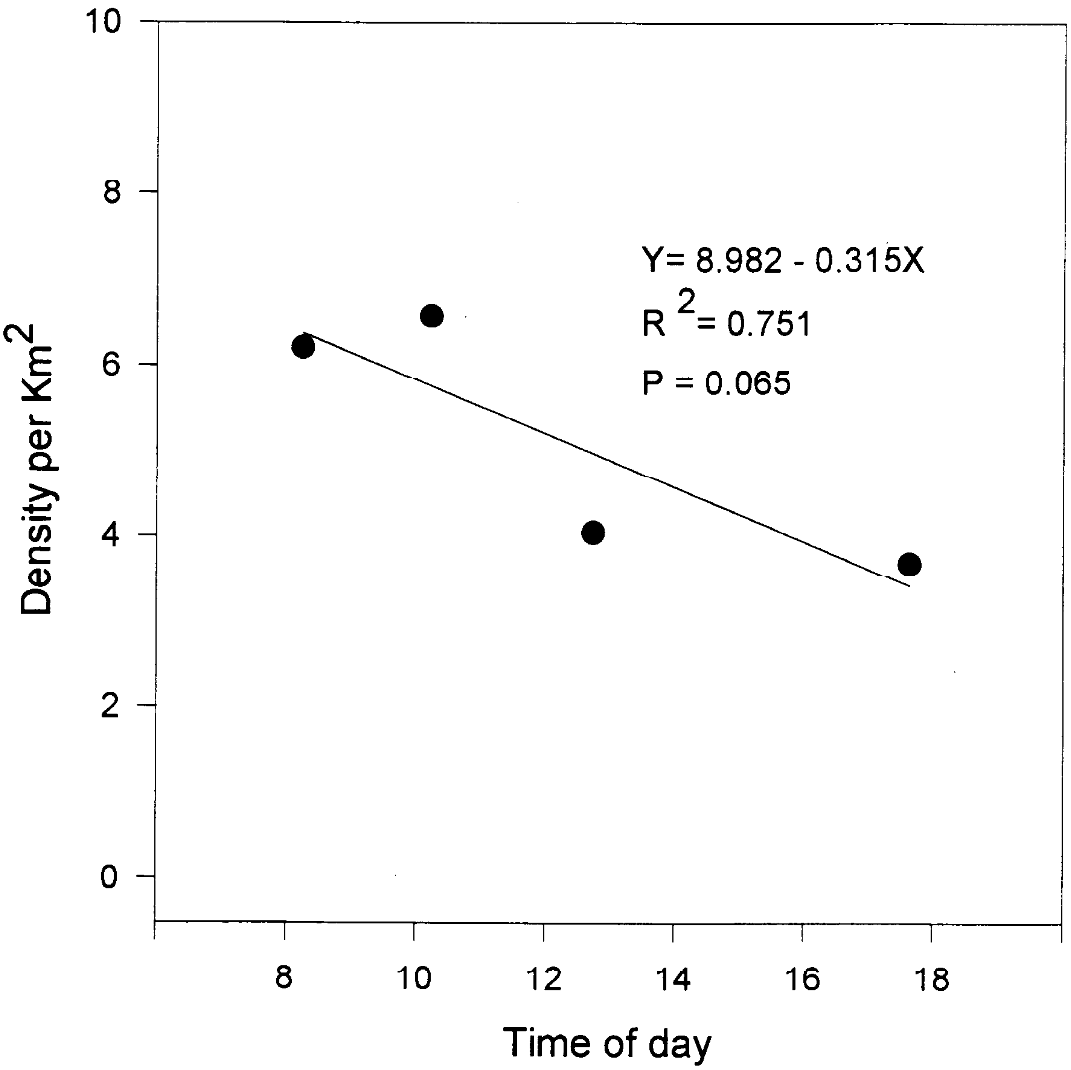

Figure 8. Summer density of Marbled Murrelets at 400 meters from shore in relation to time of day along the northern outer coast

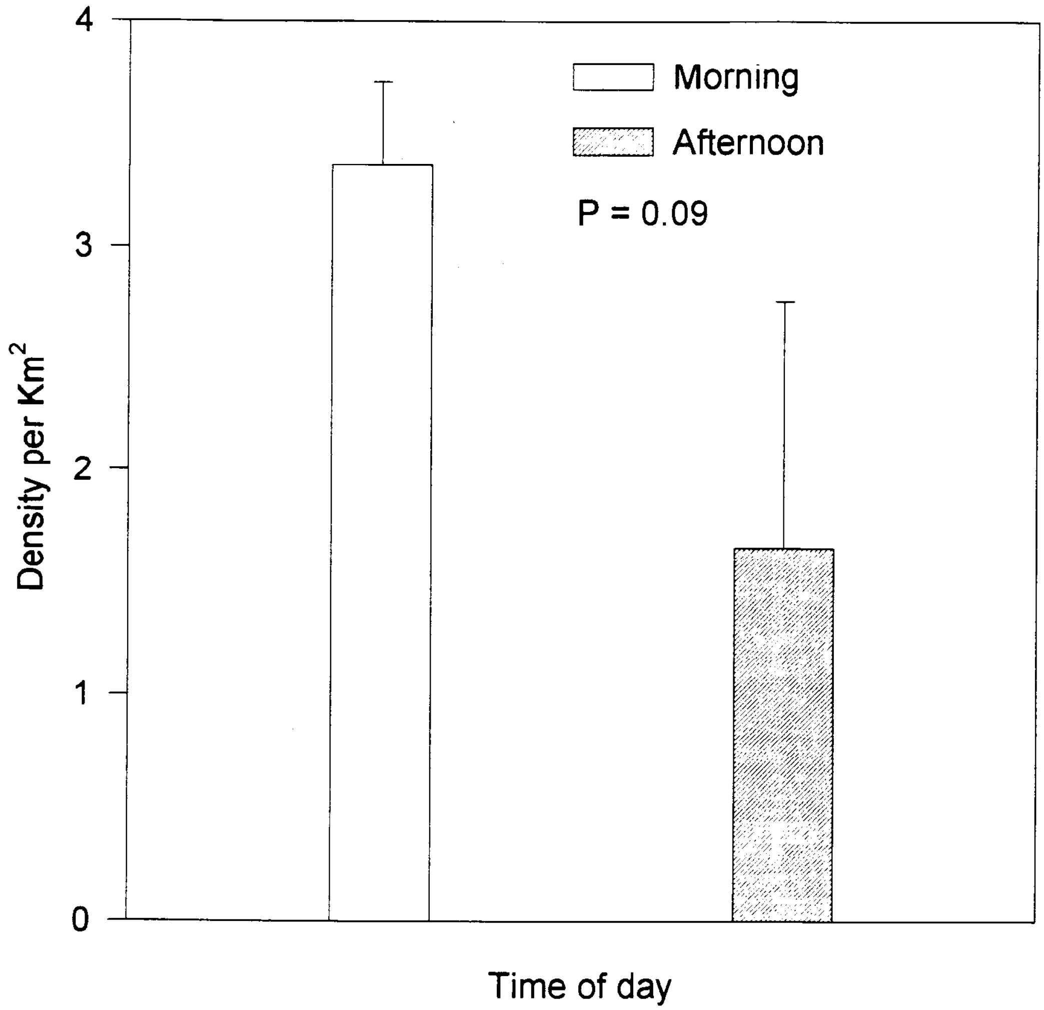

Figure 9. Summer density of Marbled Murrelets in relation to time of day along the southern outer coast.

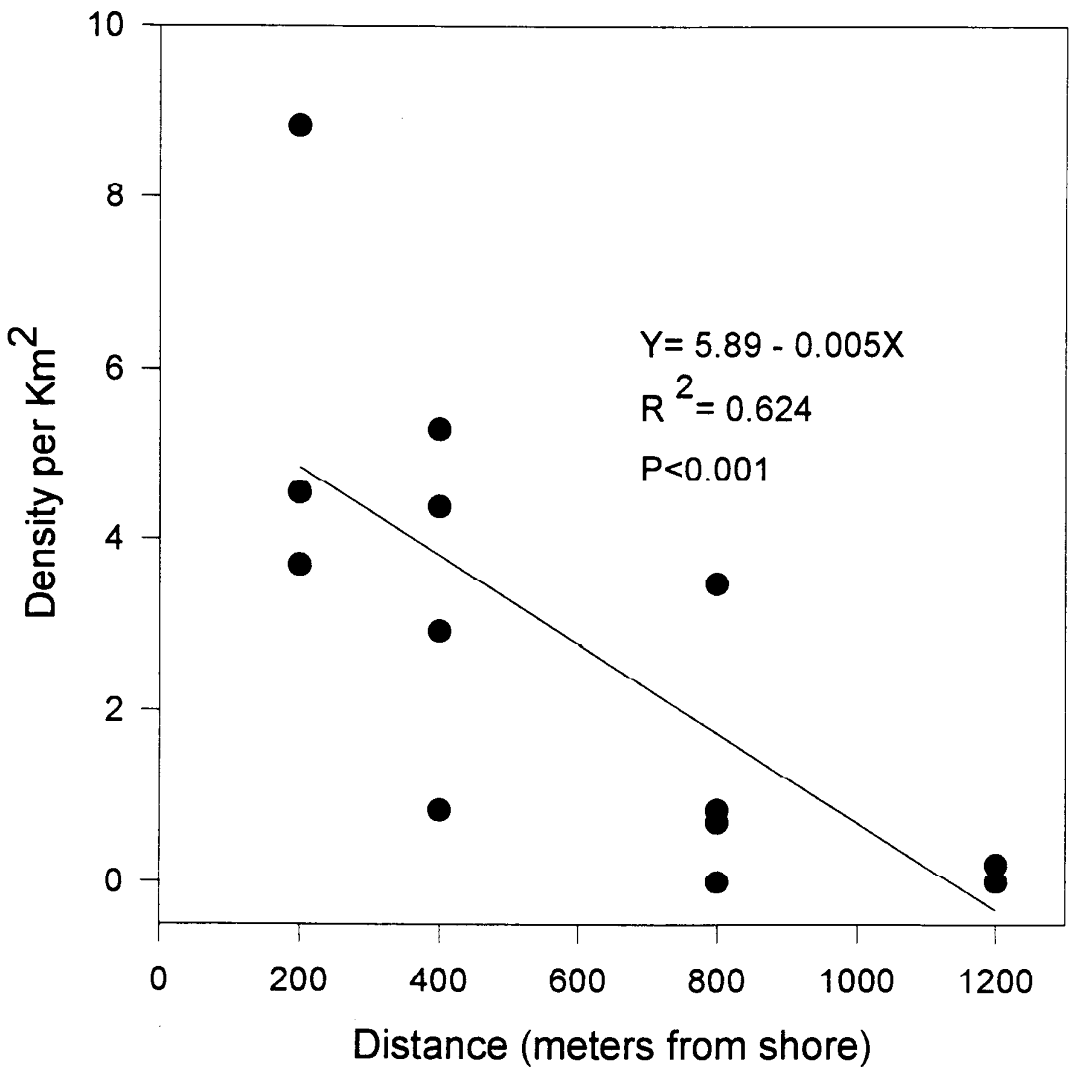

Figure 10. Summer density of Marbled Murrelets in relation to distance from shore along the outer Strait of Juan de Fuca.

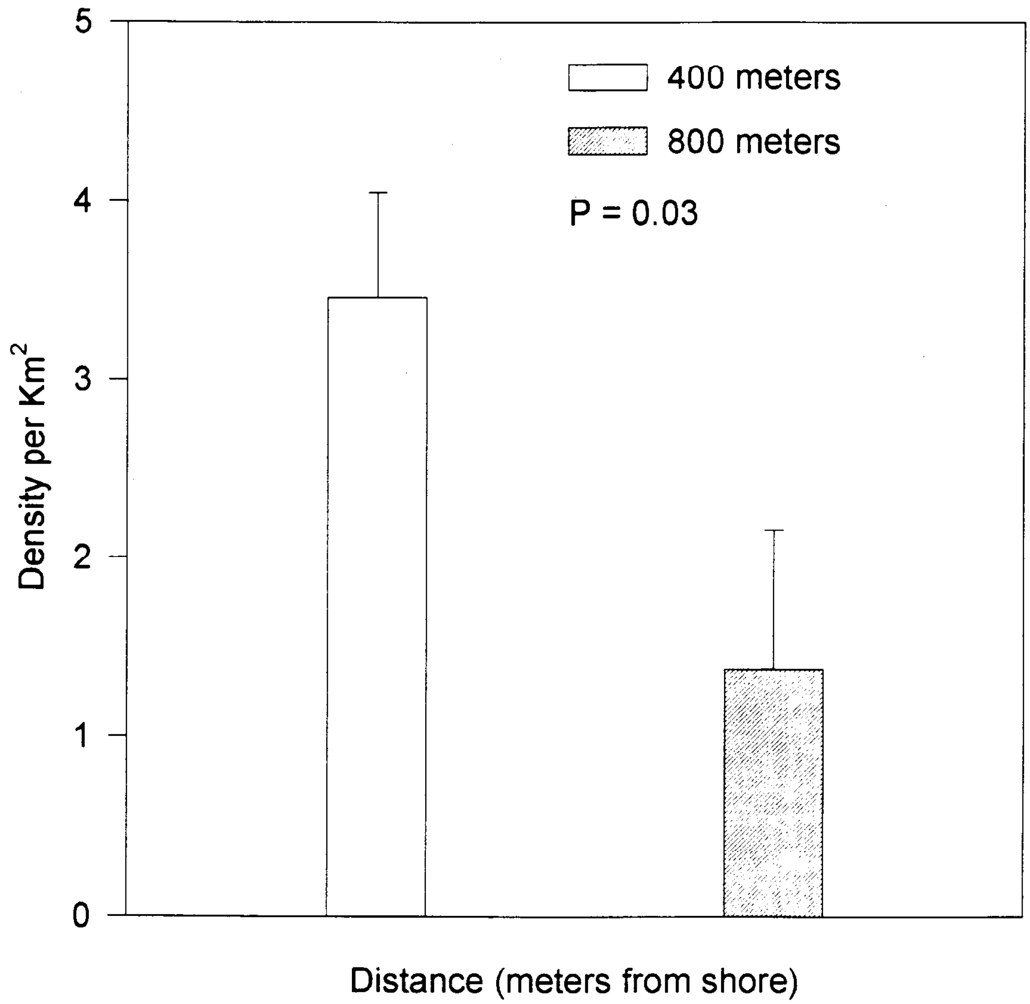

Figure 11. Summer density of Marbled Murrelets in relation to distance from shore along the northern outer coast

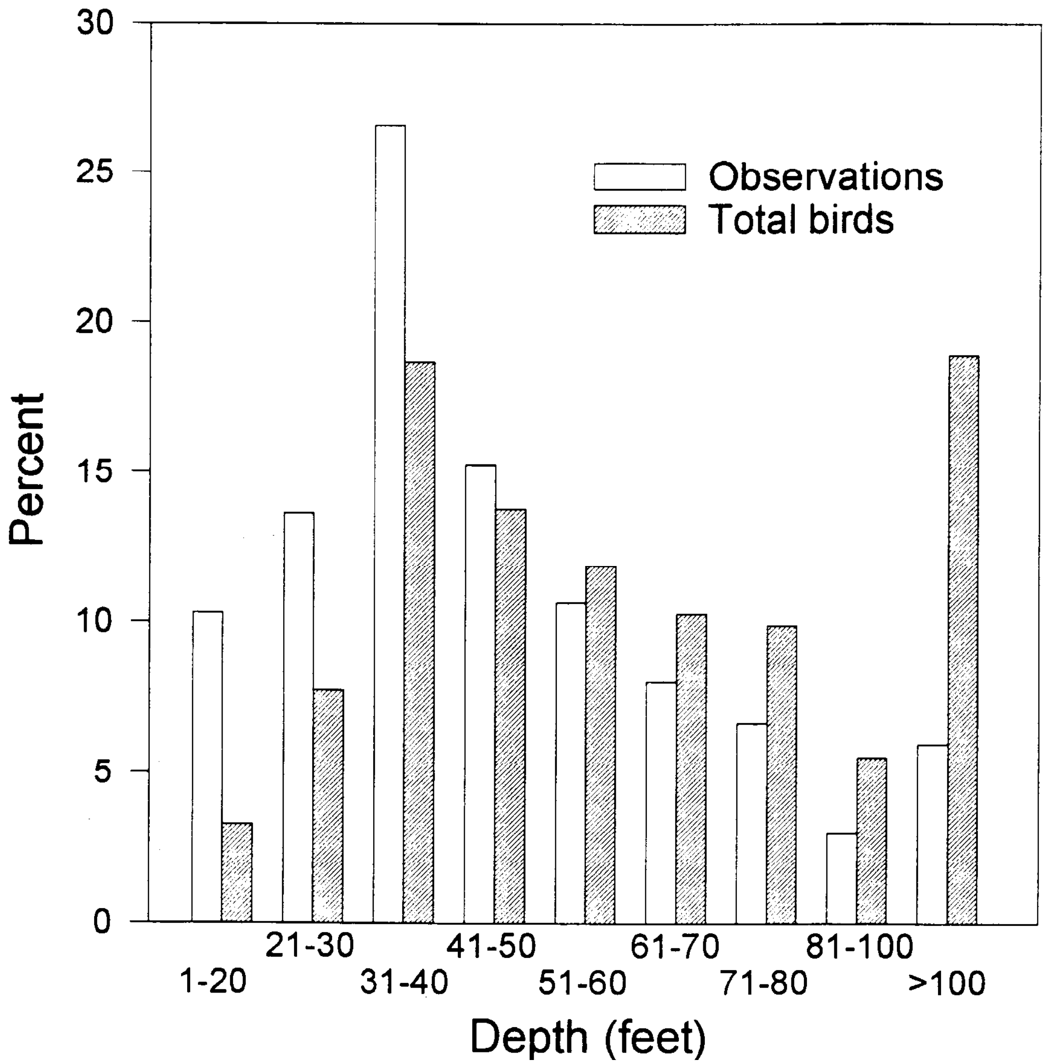

Figure 12. Frequency of occurrence of Marbled Murrelets in relation to water depth.

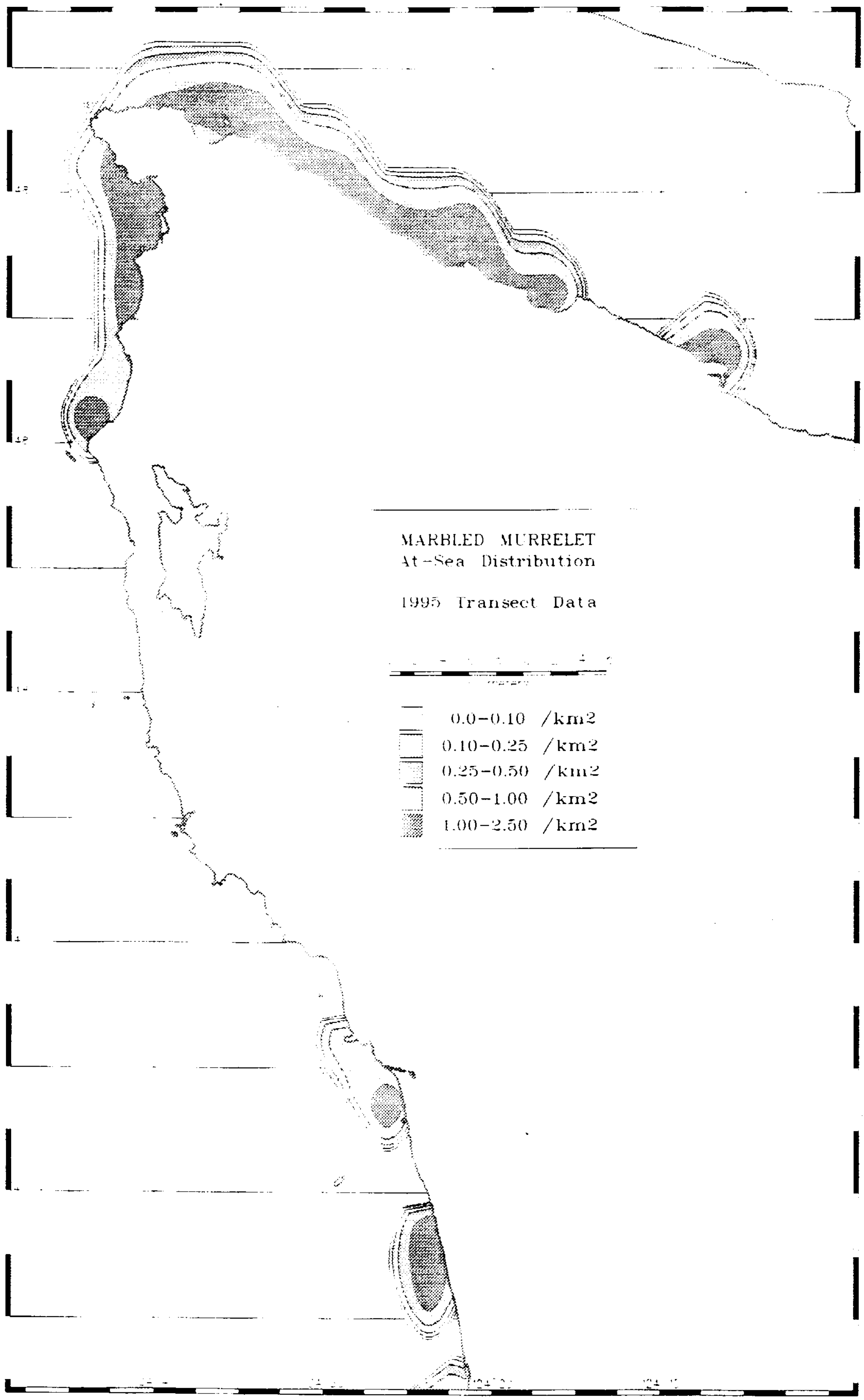

Figure 13. Summer density distribution map of Marbled Murrelets along the outer Strait of Juan de Fuca and northern outer coast of Washington.

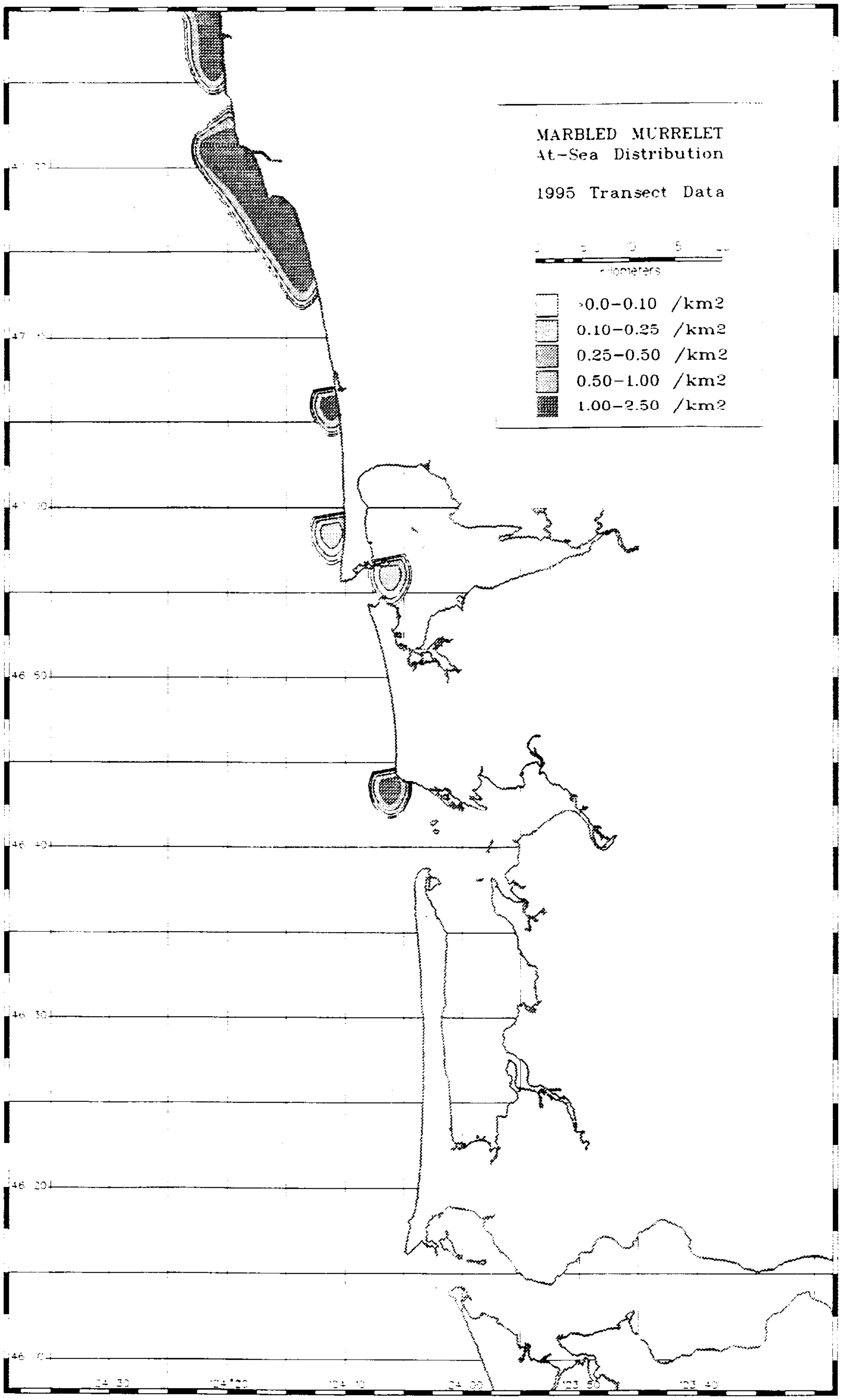

Figure 14. Summer density distribution map of Marbled Murrelets along the southern outer coast of Washington.

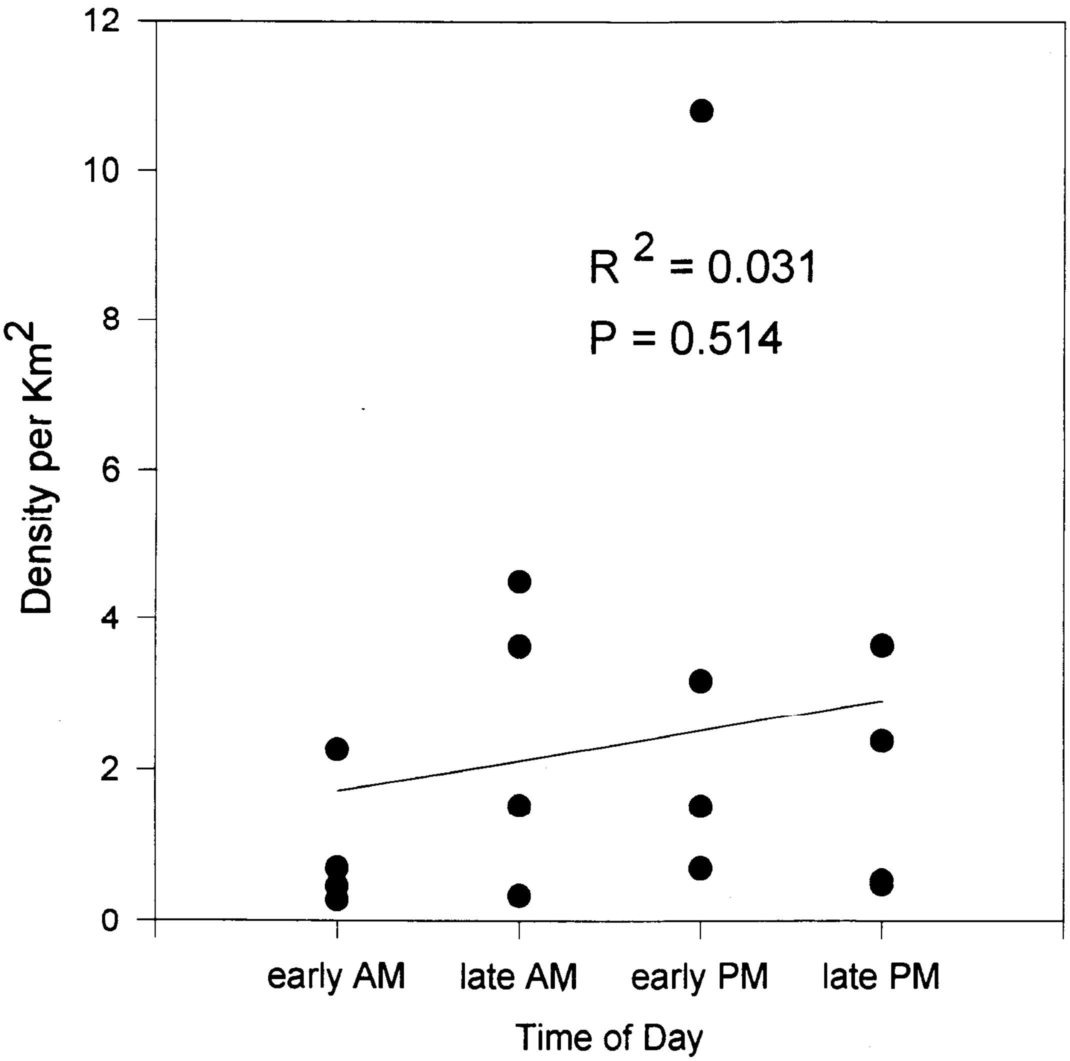

Figure 15. Summer density of Common Murres at four distances from shore in relation to time of day along the outer Strait of Juan de Fuca.

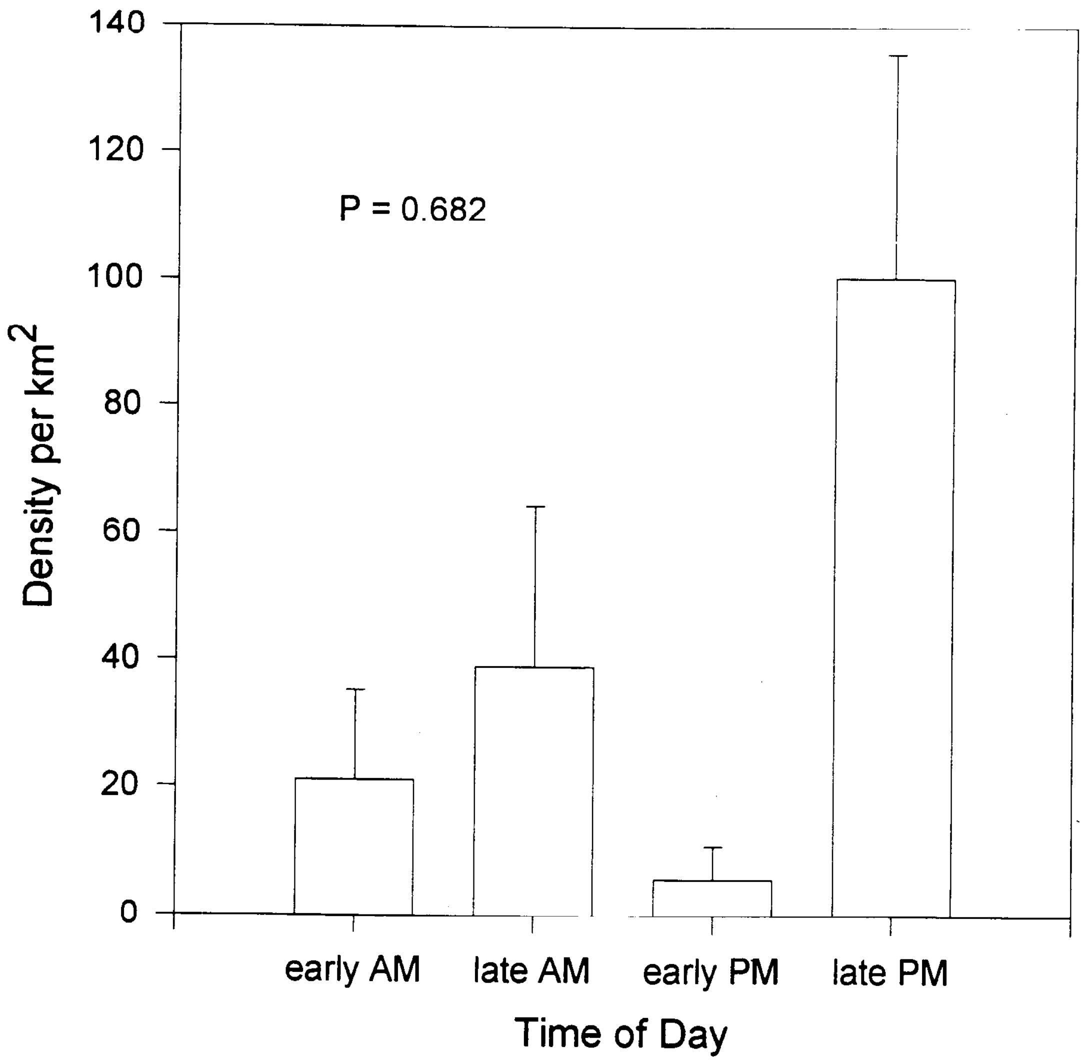

Figure 16. Summer density of Common Murres in relation to time of day along the northern outer coast.

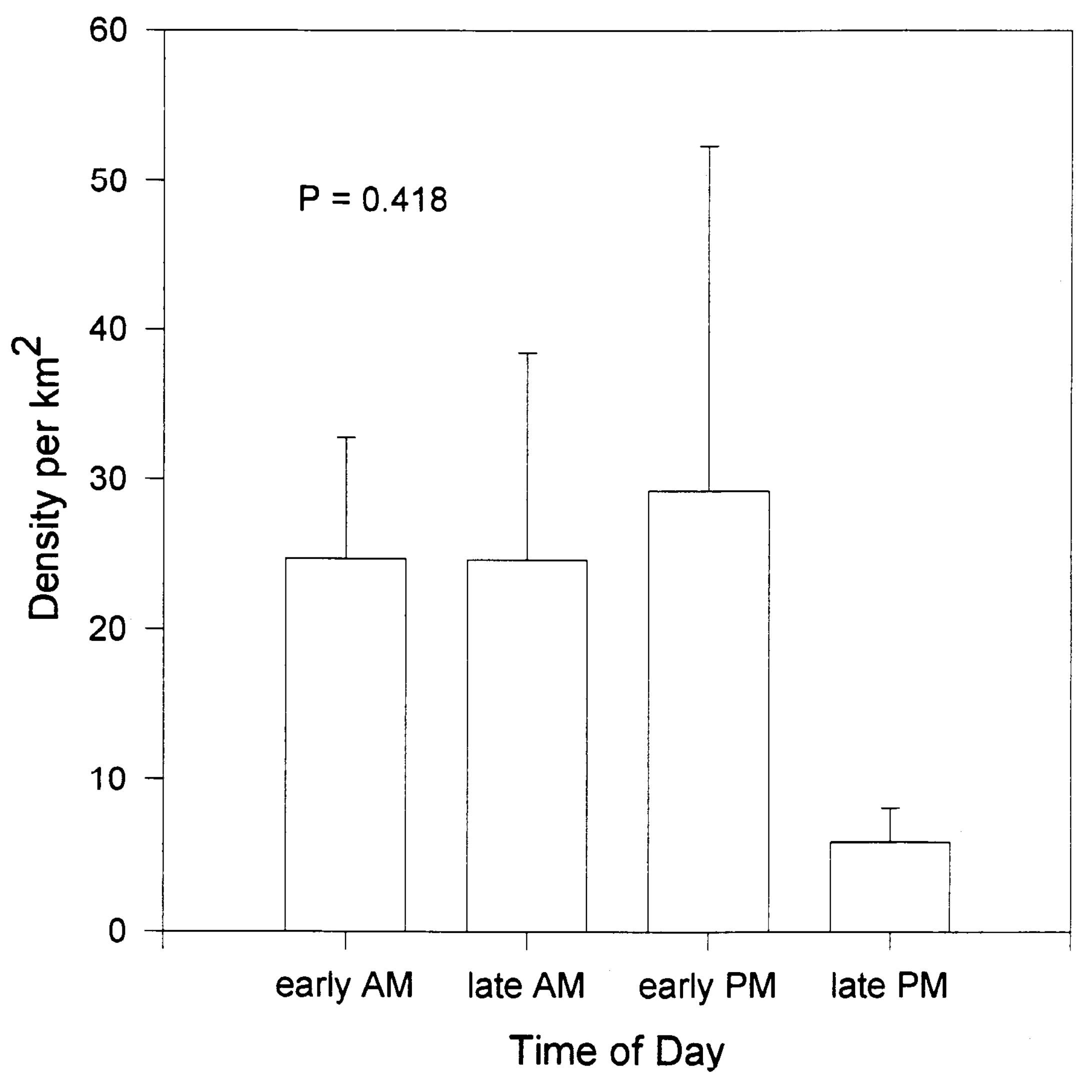

Figure 17. Summer density of Common Murres in relation to time of day along the southern outer coast.

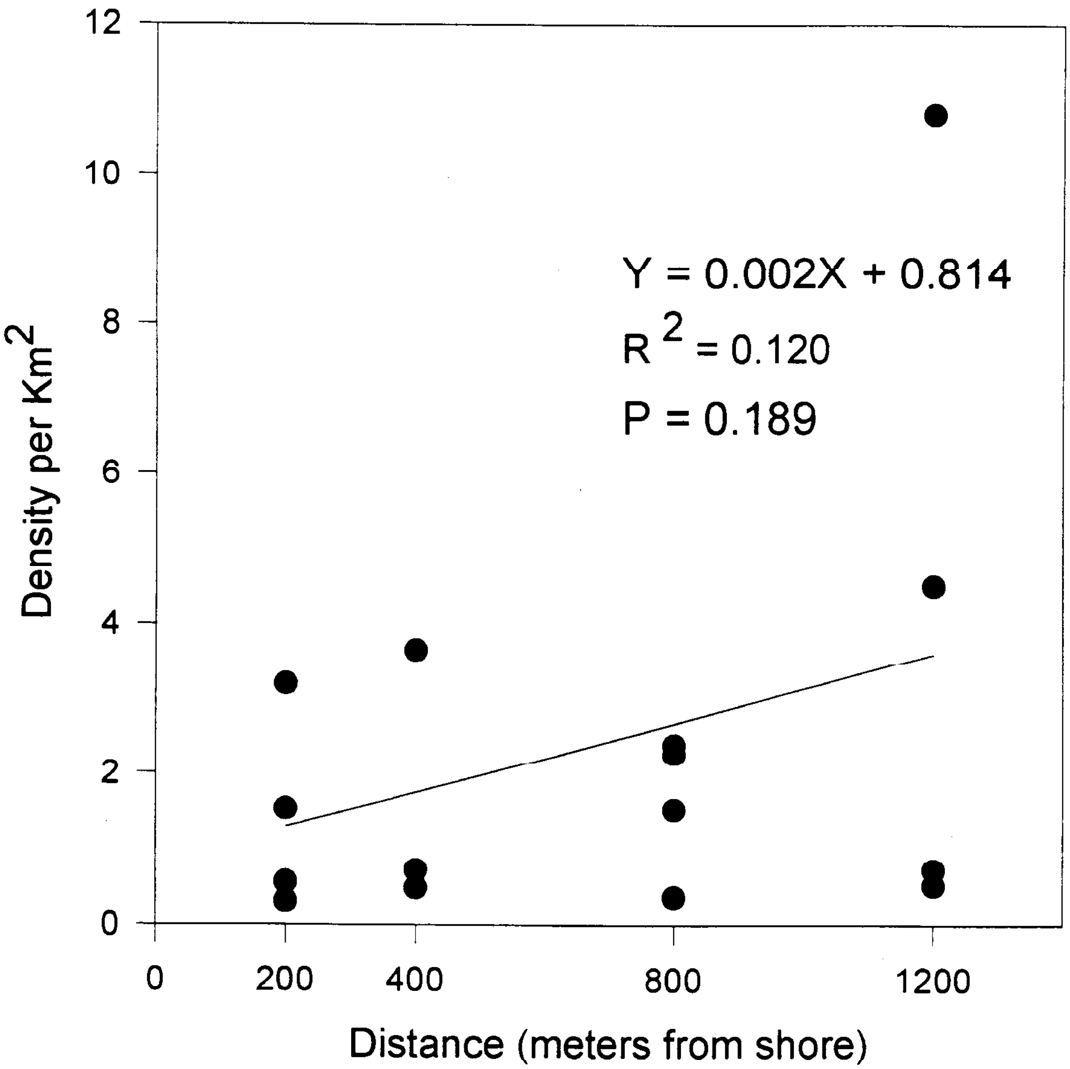

Figure 18. Summer density of Common Murres in relation to distance from shore along the outer Strait of Juan de Fuca.

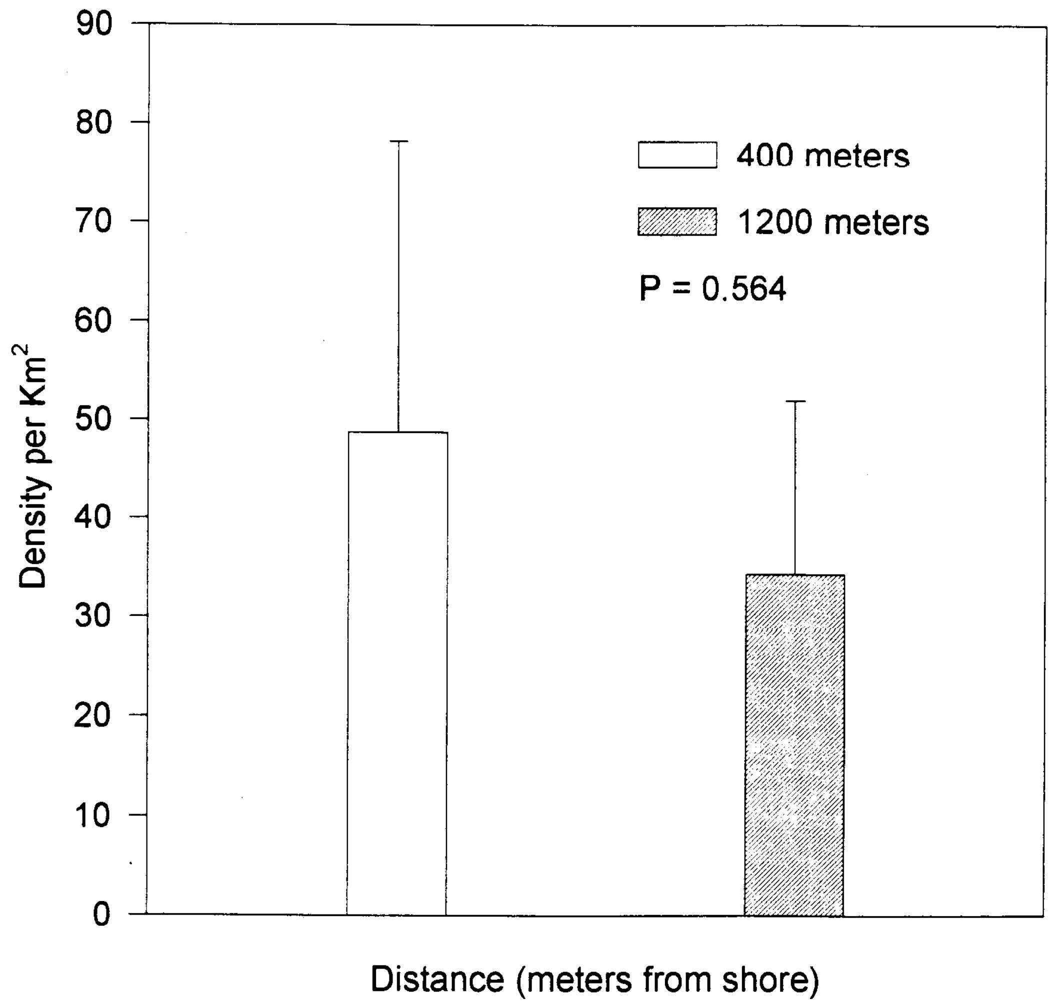

Figure 19. Summer density of Common Murres in relation to distance from shore along the northern outer coast.

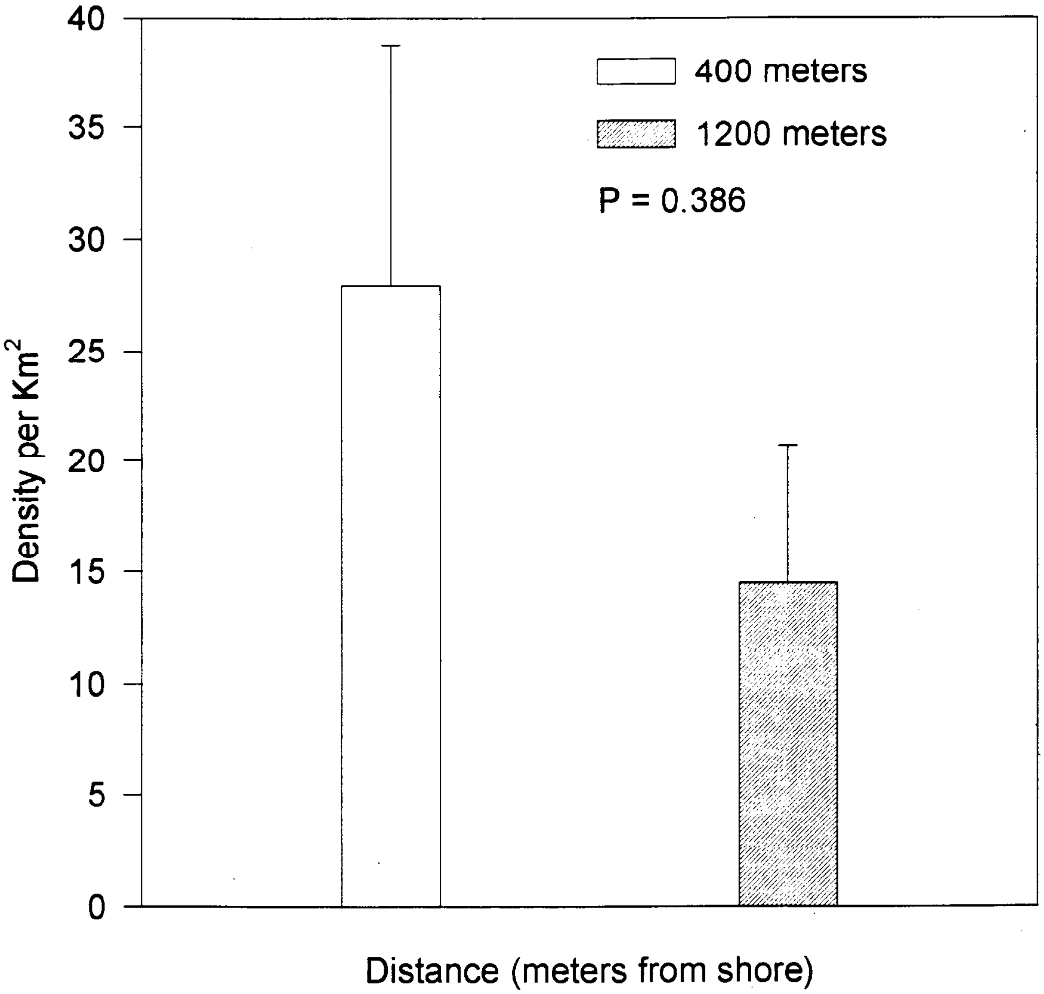

Figure 20. Summer density of Common Murres in relation to distance from shore along the southern outer coast.

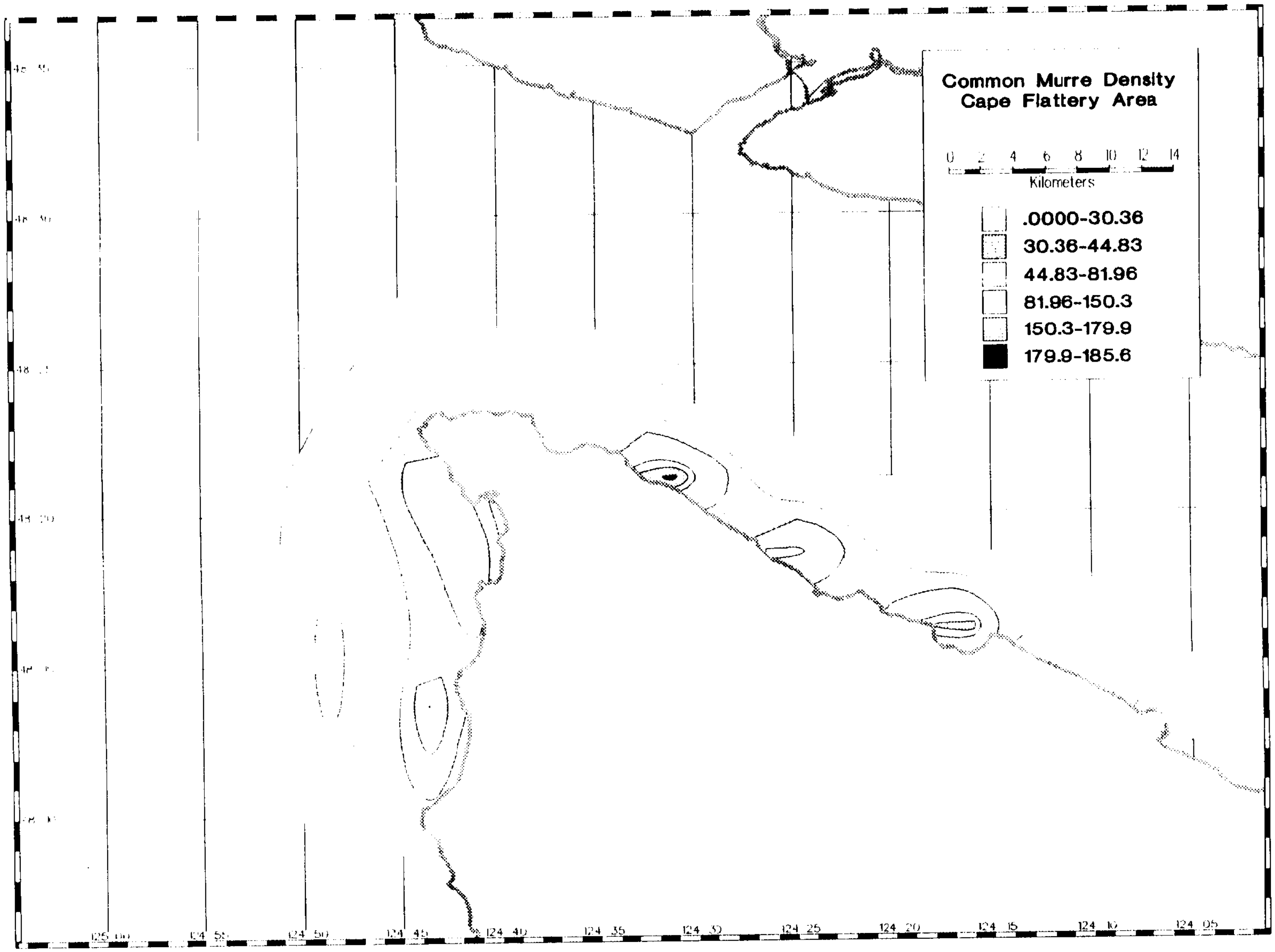

Figure 21. Summer density distribution map of Common Murres along the outer Strait of Juan de Fuca and the northern outer coast.

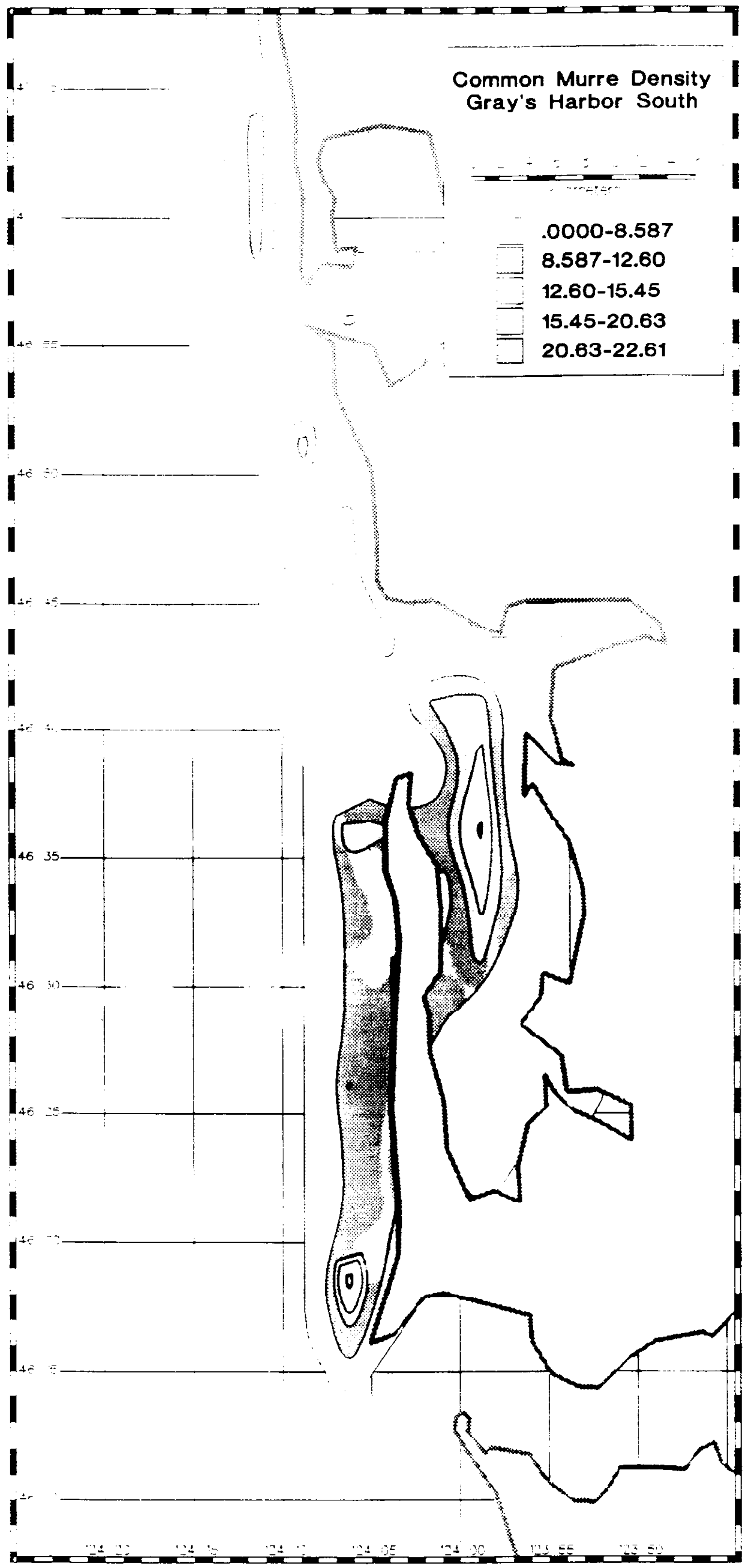

Figure 22. Summer density distribution map of Common Murres along the southern outer coast.